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The Honorable Jeffery W. Runge, M.D.
Administrator
NHTSA
400 7th Sreet, S.W
Washington DC 20590

Event Data Recorders
Docket No. NHTSA-02-13546, Notice 1

Dear Dr. Runge,

The William Lehman Injury Research Center welcomes the opportunity to comment on the value of event data recorders (EDR's) in improving the emergency care of people with crash injuries and on the role of NHTSA in advancing this technology to improve public safety. As director of the William Lehman Injury Research Center and as a practicing trauma surgeon, I am acutely aware of the difficulties that presently exist in providing rapid and appropriate care for crash survivors with time-critical injuries. My staff and I have published a number of papers in which we describe how the difficulty in quickly recognizing injuries has increased with improved occupant protection features in motor vehicles (Augenstein 1992, Augenstein 1995). The EDR technology offers the promise of providing valuable crash data that could save lives by identifying the crashes in which occupants are most likely to be injured, and even predicting the kind of injury to expect.

Based on studies of crashes in the CIREN database and in NASS, my staff and I have developed several tools to assist triage decisions and to predict specific injuries. Thefirst tool was called the "SCENE SCALE". Based on this research, in 1993, NHTSA published a Rsearch Note and distributed SCENE SCALE posters to the emergencty rescue community [Lombardo, 1993]. The posters describe crash attributes that predict the presence of time-critical injuries that might be present in crash involved occupants who "look ok" at the scene.

More recently we have been working to validate and improve the URGENCY algorithm that was developed for NHTSA by Malliaris [Augenstein 2001, Augenstein 2002, Augenstein 2003]. The URGENCY algorithm uses information available from the EDR to predict the risk of a severe injury. The application of this technology in conjunction with the Automatic Crash Notification System offers tremendous promise of saving lives by improving post-crash rescue and treatment.

The safety potential:

The National Highway Traffic Safety Administration (NHTSA) has reported that 27 million vehicles were involved in over 17 million crash events on US roadways in 2000. During these events, an estimated 2 million occupants sustained injuries requiring medical care, but only 1 in 8 sustained injuries that were considered life threatening. Although these 250,000 seriously injured occupants require the most urgent medical attention, they are not easily distinguished from the less severely injured using current rescue protocols. This inability to distinguish occupants at high risk for severe injury results in costly delays in treatment and poor allocation of medical resources.

A number of crash attributes have been recognized as important indicators of injury potential, yet the use of this information to improve rescue care has been limited to date. In the event of a motor vehicle crash, potentially injured occupants rely on passing motorists or accessible cellular technology to initiate a call for help. Once this call has been made, rescue services verbally gather location and crash severity data from callers in order to select and deploy rescue services to the crash site. A study by Evanco estimates a potential reduction of 3,069 rural fatalities if notification times within one minute of the crash are achieved [Evanco 1999]. Clark and Cushing estimate this potential fatality reduction to be 1,697 for the 1997 fatally injured population [Clark 2002].

Upon arrival to the crash, first care providers rely on anatomical, physiological and mechanism criteria to distinguish occupants who require trauma center care from those who do not. In many cases, evidence of severe internal injury is difficult to discern in the field. A large number of crash involved occupants are improperly transported to non-trauma center care before the true severity of their injuries is recognized.

Conversely, many occupants are triaged to trauma centers based on “High Suspicion of Injury” criteria in the absence of definitive evidence of injury. In this case, first care providers may choose trauma center care based on their overall impression of an occupant’s condition even if they do not meet any established trauma criteria. This use of paramedic judgment greatly improves the chance that an occupant who has sustained non-obvious or occult injuries will receive necessary trauma center care. In many cases, this practice taxes rescue and in-hospital resources.

In Miami, Florida 60% of occupants triaged to the Ryder Trauma Center under “High Suspicion of Injury” criteria are discharged within 24 hours of hospital arrival. This suggests that better methods to discern the seriously injured from uninjured in the field may help to reduce the unnecessary use of valuable medical resources.

In 1997, Malliaris conducted research that was the basis for the URGENCY algorithm to predict the risk of serious injury in the event of a motor vehicle crash [Malliaris 1997]. The algorithm processed crash conditions using logistic regression models to predict the likelihood of AIS3 or higher injury for crash involved occupants. A single regression model was developed to predict injury risk for all crash modes based on characteristics known to be influential for injury outcome.

Our 2003 ESV paper supports further implementation and enhancement of Automatic Collision Notification technology to improve crash rescue care. Further development of the URGENCY algorithm is described and its predictive ability is documented through an analysis of real world crash cases. Four independent injury models by crash mode were developed. Each algorithm was created in two levels of complexity and tested for its accuracy. Model performance is also compared with the use of deltaV alone as an independent predictor of injury. The paper provides information on the crash parameters that if recorded in the EDR would assist in predicting serious injuries. In addition, the relative benefit of collecting each additional data element is indicated.

STUDY SUMMARY

Predictive models have been developed which utilize a series of crash attributes to estimate the likelihood of MAIS3+ injury. These models were created in three levels of complexity to understand the relative benefit of additional variables during the estimation of injury likelihood. The study indicated that the accuracy of injury predictions improves significantly with the addition of selected variables; however, this improvement depends heavily on crash mode. The most influential variables are those shown below:

1. Lateral DeltaV (for each impact event)
2. Longitudinal DeltaV (for each impact event)
3. Lateral Acceleration Profile
4. Longitudinal Acceleration Profile
5. Three Point Belt Usage (all occupied positions)
6. Airbag Deployment (in occupied positions)
7. Intrusion Extent
8. Occupant Age
9. Occupant Height/Weight
10. Rollover Occurrence
11. Occupant Ejection

During the study, logistic regression models were created based on historical crash data to process crash attributes readily available through on-board vehicle sensor systems and on-scene observations to predict MAIS3+ injury risk for frontal, nearside, farside and rear impacts. These models were subsequently evaluated using an independent set of crash cases to understand the ability of each model to distinguish seriously injured occupants within the total population of crash involved occupants.

The predictive ability of models constructed in three levels of complexity was compared. The first model utilized crash mode and deltaV threshold as a simple criterion for Automatic Crash Notification (ACN) devices. Sensing, processing and transmission of this data alone would adequately detect close to 64% of the MAIS3+ injured population. With the addition of information regarding 3-point restraints usage and airbag deployment, the accuracy of injury recognition improves only slightly to 67% but the occurrence of mis-classifications declines nearly 10%. With the addition of crash attributes shown in the list above, proposed models correctly identified 74.2% of the MAIS3+ injured occupants involved in tow-away crash events for NASS/CDS Cases from 2000 and 2001. 12.5% of the uninjured population was incorrectly classified as injured for this population.

The usefulness of each crash parameter shown above varied significantly between crash modes. For each optimized combination of variables by crash mode, the overall accuracy of each model at a given threshold level are as shown in Table A below. Within the following text, a mode detailed description of the model development and validation process is presented. Further information regarding the predictive accuracy of models is given in the paper.

Mode	Cutoff Probability	Sensitivity	1-Specificity
Frontal	19.2%	70.1%	11.2%
Nearside	29.7%	80.7%	18.0%
Farside	17.0%	78.3%	14.3%
Rear	8.4%	71.4%	11.2%
Total		74.2%	12.5%

Table A. Optimised Model Accuracy by Crash Mode

It is well understood that rapid notification of rescue services and appropriate administration of medical care will reduce the likelihood of secondary injury or death of crash involved occupants. Methods to process crash conditions in order to estimate the likelihood of injury have been established and the accuracy of these methods has been reported. When compared with injury prediction based on deltaV alone, proposed models were shown to improve accuracy of injury estimates based on crash attributes available at the time of the crash. Additional crash attributes must be recorded for subsequent processing by predictive models and transmission.

For the NASS/CDS populations tested, the sensitivity of models predicting the likelihood of MAIS3 and higher injuries is 74.2% with an overall specificity of 87.5%. When compared with predictions based on deltaV alone, the use of proposed models offers a more accurate estimate of injury potential based on readily available crash information for frontal crashes and farside crashes. This improved accuracy is not readily observed for nearside and rear crashes.

In order to make use of any injury model including those based only on deltaV, methods to automatically collect, store and deliver crash information to the most appropriate individuals must be implemented. This effort will require continued cooperation between auto manufacturers, rescue providers and in hospital clinicians to collectively agree upon the most appropriate methods to reach this goal.

NHTSA's Role In EDR development

NHTSA needs to encourage the technology to save lives by improving post-crash emergency care. To this end, NHTSA needs to sanction an injury predicting algorithm that incorporates the data from the EDR. NHTSA should set minimum standards for the data to be transmitted and should standardize the format. Finally, NHTSA needs to provide training and training materials to all segments of the post-crash service and care professionals so that the critically injured crash victims will benefit from the ACN/EDR technology.

References:

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